PATENT SPECIFICATION

677,824

Date of Application and filing Complete Specification Jan. 23, 1950.
No. 1743/50.
Application made in France on Jan. 22, 1949.
Application made in France on Jan. 22, 1949.
Application made in France on April 5, 1949.
Application made in France on April 5, 1949.
Application made in France on April 5, 1949.
Application made in France on Nov. 8, 1949.
Application made in France on Nov. 8, 1949.
Complete Specification Published Aug. 20, 1952.

Index at acceptance :—Classes 9(i), C1a(1 : 3), C5d ; and 38(v), B(1n4 : 2a13e).

COMPLETE SPECIFICATION

Improvements in Devices Containing Hollow Explosive Charges for Perforating or Cutting Bore-hole Linings or Casings

PATENTS ACT, 1949

SPECIFICATION NO. 677,824

In pursuance of Section 8 of the Patents Act, 1949, the specification has been amended in the following manner:-

Page 6, line 63, *after* "blast" *insert* new paragraph:-

> "We are aware of Patent 686,530 which discloses an apparatus for perforating a well casing or well wall comprising a hollow sealed housing capable of being inserted in the well, means for positioning said housing in the well, at least one explosive charge having an outwardly facing cavity mounted within said housing, said housing defining an expansion chamber partly or wholly surrounding said explosive charge or charges, and means for detonating said explosive charge, and make no claim to anything contained therein."

Attention is also directed to the following Printer's Errors:-

Page 2, line 24, *for* "propogation" *read* "propagation".
Page 4, line 118, *after* "is" *insert* "in".
Page 6, line 3, *for* "than" *read* "that".
Page 6, line 90, and page 6, line 91, *for* "centering" *read* "centreing".
Page 7, line 28, *for* "herein described" *read* "hereindescribed".

THE PATENT OFFICE,
19th April, 1954

DB 43910/1(1)/3386 150 4/54 R

charges being effected by lateral introduction into said cylindrical body. The cylindrical body may be hollow over its whole height or simply comprise cavities, preferably disposed one above the other, and into which the charges are introduced, said cavities providing laterally.

Furthermore, in order to prevent the intrusion of water or mud into the apparatus and so by suppressing the air-filled cavities, causing, at the time of the explosion of the charges, the explosion of the apparatus itself and of the casing, devices are provided to prevent the firing of the hollow charges if this intrusion has

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COMPLETE SPECIFICATION

Improvements in Devices Containing Hollow Explosive Charges for Perforating or Cutting Bore-hole Linings or Casings

We, SOCIÉTÉ DE PROSPECTION ELECTRIQUE PROCÉDÉS SCHLUMBERGER, a Body-Corporate organised under the laws of France, of 42, Rue Saint-Dominique, Paris VII, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to devices containing hollow explosive charges for perforating or cutting casings lining the walls of bore-holes.

The invention aims in particular at providing multiple-blow casing-perforating apparatuses of great efficiency and offering great safety in use with regard particularly to the danger of casings bursting.

It has likewise the object of providing apparatuses of this kind, in which the placing of the charges is effected individually for each charge.

It aims also at permitting regular and regularly distributed firing of said charges.

To this end, the present invention consists in a device containing hollow explosive charges for perforating or cutting casings lining the walls of bore-holes, comprising a plurality of explosive charges mounted in an elongated cylindrical steel body, the positioning of said charges being effected by lateral introduction into said cylindrical body. The cylindrical body may be hollow over its whole height or simply comprise cavities, preferably disposed one above the other, and into which the charges are introduced, said cavities providing laterally, in relation to the hollow charges, spaces filled with air or with compressible materials in order to prevent the breakage of the steel of the body by the explosive.

Each of the chambers is preferably closed by a cap capable of withstanding the external hydrostatic pressure, and which is adapted to be pierced by the blast of the explosion of the charge, such cap being preferably held in place by a spring device.

The firing of the various charges is preferably done by means of a detonating fuze traversing the rear part of each charge, said fuze extending preferably from one chamber to the next through an orifice drilled along the longitudinal axis of the body of the apparatus. The firing of the fuze is preferably effected by a detonator and electric igniter disposed at the bottom of the apparatus, and the electric conductor connecting the igniter to the source of current placed on the surface of the ground passes through the aperture, either axially alongside the detonating fuze, or in a groove, preferably helicoidal, cut along the surface of the steel body and disposed in such manner as not to decrease the strength of the said steel body or block.

Centering means may be provided for the various charges in the interior of the cylindrical block.

Furthermore, in order to prevent the intrusion of water or mud into the apparatus and so by suppressing the air-filled cavities, causing, at the time of the explosion of the charges, the explosion of the apparatus itself and of the casing, devices are provided to prevent the firing of the hollow charges if this intrusion has

taken place. Moreover, with regard to the hollow charges themselves, they are conveniently provided with a jacket preferably made of a plastic and resilient substance, such as elastic rubber, having a channel at their rear part in order to permit the passage of the detonating fuze.

The device may have a conical metal liner which is placed in the cavity of the explosive charge, said liner being preferably manufactured of a substance or a metal such as zinc having a vaporisation temperature of below 600° C.

Moreover, behind the charge or each charge intended to effect the perforation, cutting or the like, it is advantageous to dispose further charges, known as firing charges, separated from the first-mentioned charges by a chamber of relatively small dimensions and empty or filled with porous inert matter which permits the ignition to be regularised and the ignition wave to be propogated in a well directed manner and at high speed.

Other objects and characteristics of the invention will appear during the course of the following description relating to the attached drawings which illustrate, schematically and by way of non-limitative examples, various particular embodiments of the invention.

Fig. 1 is a partial longitudinal section of a casing perforating block intended to receive various charges and designed according to the invention.

Fig. 2 is a transverse section along line II—II of Fig. 1, the cartridge containing the hollow charge not being shown in section and is viewed from above.

Fig. 3 shows a detail.

Fig. 4 is an overall view on a smaller scale showing the device according to the invention placed in the working position inside a bore-hole.

Fig. 5 is a similar section to Fig. 2, of a variant of the device shown in the preceding figures.

Fig. 6 is a section of the lower part of a perforator of the same type as that described in Fig. 1, but comprising in addition a device intended to prevent firing in the case of the intrusion of water into the apparatus.

Figures 7 and 8 show two variants of the device intended to prevent firing in the event of intrusion of water.

Figs. 9 and 10 show another variant of this same device, Fig. 9 being in the engaged position and Fig. 10 in the disengaged position as a result of the intrusion of water.

Figs. 11 and 12 show other variants of this same device.

Figs. 13 and 14 show respectively in longitudinal, vertical and transverse sections a variant of the perforator shown in Fig. 1.

Finally, Fig. 15 shows an embodiment of hollow charge comprising a firing charge separated from the hollow charge proper by a space which can be empty or filled with porous material.

On referring more particularly to Figs. 1 and 2, 1 designates the body of the apparatus constituted by a cylindrical steel block, of high grade steel in which have been drilled radially one above the other and in different azimuths (perpendicular to each other in the embodiment illustrated), cylindrical cavities 2, 2^1, 2^{11} and so on, each having an outlet aperture on one side of the block.

The various cavities 2, 2^1, 2^{11} communicate with each other by means of channels 3, 3^1, 3^{11} and so on, disposed along the longitudinal axis of the cylindrical block. Inside each of the cavities is mounted a hollow charge, disposed in an external jacket 4 which is preferably of a plastic or elastic substance, for example rubber, the effect of which is to ensure that at the time of the explosion of the charge, the hurling of the fragments of said jacket against the internal wall of the apparatus does not risk damaging said wall. Moreover, the rubber used will preferably be soluble in hydrocarbons, so that the fragments of the jacket which are hurled into the bore do not risk blocking up the perforations made.

In the interior of this jacket is disposed the explosive charge 5, in front of the forward part of which is placed a conical liner 6, terminating in a cylindrical member 7, intended to be applied against the inner wall of the jacket 4, so as to centre the cone 6 in the jacket. The liner and cylindrical member 6, 7 is preferably manufactured of a substance, and in particular of a metal or metal alloy, having a vaporisation temperature below 600° C, such as, for example, zinc or an alloy of zinc, magnesium, and the like, so that at the time of the explosion the said piece is completely volatilized and there is no risk of its forming itself into a block and at least partly obturating the perforations made. The jacket of the hollow charge is centred in the interior of the chamber 2 by two washers, 8 and 9, for example of cardboard, the rear washer 8, which has been shown separately in Fig. 3, comprising notches 10 and 10^1 for the passage of the fuze, as will be explained hereinafter.

In front of the hollow charge, and at the entrance of chamber 2, is disposed a cap 11, which is applied by means of a packing 12 against the body of the apparatus 1, and is held in position by a

spring blade 13, inserted laterally in slots 14, 14^1 provided for that purpose in the body of the apparatus. The cap 11 is preferably of a friable and relatively dense material, (for example cast iron). The thickness of the cap, particularly at its centre part, is chosen so that it can withstand the hydrostatic pressure existing in the bore-hole, without however offering excessive resistance to the blast of gases produced by the explosion of the hollow charge.

The relative volumes of the charge and of the chamber containing it are so selected that the shock wave produced by the explosion of the charge does not risk splitting the walls of the apparatus. The design proposed, in addition to the strength of the walls which it provides, has the advantage of reflecting the various shock waves produced by the simultaneous explosion of a plurality of charges, thereby reducing the fatigue imposed on the casing.

The ignition of the various charges is effected by a fuze 15, which passes from one chamber to another by traversing the apertures 3, 3^1 and so on, and is inserted at the base of each of the charges 5 through a slot provided at the rear part of the rubber jacket 4 of said charge, said slot having preferably the form shown, so as to keep the fuze in place when it is inserted in said slot.

The ignition of said fuze is effected in *per se* known manner, preferably at the bottom of the apparatus by means of a detonator and an electrical firing device. The conductor wire, (not shown in the drawing) intended to ignite the electric detonator, passes preferably through the same hole as the fuze. It is connected to the electric cable which supports the apparatus inside the bore-hole and is connected at ground level, in *per se* known manner, to a source of electric current.

The embodiment illustrated in Fig. 5 differs from the previous embodiment in that the apertures provided in front of the cavity 2, to allow the introduction of the charge, is of reduced diameter, corresponding exactly to that of the charge which it is desired to introduce; the front cap. in this embodiment, is screwed for example at 16 into the body of the apparatus. So that the chamber may nevertheless be of sufficient dimensions in relation to the volume of the charge, said chamber is flared out behind the screw thread, as can be seen in the figure.

Figures 6 *et seq.* show, as has been stated above, the furnishing of a perforator of the type which has just been described, with devices preventing the firing of the charges if an intrusion of water into the chambers takes place.

Said devices can be based on different principles; in the case of electric ignition, they can operate in such manner as to prevent the passage of the current through the ignition filament; they can also be based on the damping of the ignition powder, which can then no longer ignite. In the first case it will, in particular, be possible to provide float devices which, under the effect of the intrusion of water, will short-circuit the ignition filament. It will also be possible to arrange short-circuiting through the impregnation with water of the textile insulations provided for the current supply wires. It will also be possible to provide mechanical breaking of ignition circuits, caused by the separation of wires held together, for example against a spring action, particularly by devices such as strips of gummed cloth which come unstuck under the action of water. It will likewise be possible to provide, as has been stated above, for the direct action of water or liquid on the firing charges, said action being facilitated by the fact that the jacket of said charges is made of substances which can be permeated with water and the like.

In Fig. 6, as in the preceding Figs., 1 designates the lower wall of the body of a perforator with hollow charges, inside which are provided superposed cavities 2, 2^1 and so on, intended to receive hollow charges 5, 5^1 and so on, the firing of which is effected by means of the detonating fuze 15.

11 designates the closure cap of the chambers 2, containing the hollow charges 5. Below the chamber 2^1 situated lowest in the block 1, is disposed another smaller chamber 16^1, containing the end 17 of the detonator fuze at which the said fuze is fired; 18 designates a sealing plug intended to close said chamber. The firing of said fuze is effected, in *per se* known manner, by means of a heated electric filament, the extremities of which end at the current supply wires 19 and 19^1. According to the invention, the current supply wires 19 and 19^1, instead of being connected directly to the electrical conductors which connect them at ground level to the electricity supply source effecting the firing, are connected in the manner shown and penetrate separately into a chamber 20, disposed below chamber 16^1, where they are connected to metal contacts 21 and 21^1 supported by an insulating sleeve 22, and it is beyond said contacts 21 and 21^1 that said conductors, passing in the opposite direction through the chamber

and the various chambers 2, 2^1 and so on, rejoin the support cable intended to support the apparatus 1 inside the bore-hole. The chamber 20 is tightly closed at the bottom by a plug 23, and inside said chamber is disposed a metal float 24. It can easily be seen that in the case where, as the result of any lack of tightness, water penetrates inside the apparatus, said water will begin to accumulate inside chamber 20 and the float 24, by rising, will short-circuit contacts 21 and 21^1, thereby preventing the passage of sufficient current through the ignition filament to effect the firing of the fuze.

The device illustrated in Fig. 7 differs from the preceding one in that the wires 19 and 19^1, covered solely with a slight insulation of textile material, are wound inside chamber 20 on a metal mandrel 25. In the case of water filling the chamber 20, the textile coverings of the wires 19 and 19^1 would lose their insulation and short circuit on the metal mandrel 15.

In Fig. 8, one of the conductor wires 19^1 leading to the ignition device is mounted direct on the block at 40 and the circuit therefore comprises only one supply conductor wire 19 with earth return. Furthermore, said conductor wire 19 is in direct contact at a point 33 with a tubular metal member 41, mounted inside the body of the apparatus from which it is insulated by any suitable device, for example by means of textile material. A resistance 42 is inserted in series on the conductor 19, between the point where said conductor terminates at the ignition member and the point 43 where it is in contact with the tubular member 41. Beyond said point 43 the conductor wire is connected, at ground level, to the current supply source, as in the preceding case.

It can easily be seen that when the apparatus does not contain water, the tube 41 being insulated, the closing of the circuit at ground level causes the current to pass through the igniter 17, and consequently effects ignition of the detonating fuze. If on the other hand water penetrates inside the apparatus, said water, by moistening for example the external textile fibres which separate the member 41 from the body of the apparatus, produces a partial earthing of this member 41. From that moment, if the supply circuit is closed, and by reason of the presence of the resistance 42, the greater part of the current flows no longer through the wire 19, but directly from the tube 41 to earth, and the small part of said current passing through the igniter is insufficient to operate it.

The device illustrated very schematically in Figs. 9 and 10 differs from the preceding ones in that the filament is no longer short-circuited but a complete break in the circuit going to said filament is obtained. In these Figs., 17 designates, as previously, the ignition device of the detonating fuze at which terminate the wires 19 and 19^1 serving to supply the ignition filament. In this case the wire 19^1 is earthed at 26 (for example to the mass of the apparatus), whereas the conductor 19 is connected by means of two contacts 30 and 30^1 to the conductor 27; the other end of said conductor 27 is connected at ground level to one of the terminals of the source of current, the other terminal of which is earthed by means of the firing switch. The two contacts 30 and 30^1 are themselves carried by the two ends of a safety-pin type spring 28, and are held against one another by means, for example, of a strip of gummed cloth 29. The whole of the device 28—29—30—30^1 is assumed, as in the preceding case, to be placed inside a chamber 20 which is right at the bottom of the perforator. When said chamber 20 fills with water, the gummed strip becomes detached (Fig. 10) and, under the action of the spring 28, the two contacts 30 and 30^1 separate at the same time as the contact 30 is earthed at 32. Current can therefore no longer pass to the ignition filament.

In the devices illustrated in Figs. 11 and 12 firing is made impossible by actually wetting the powder, explosive or ignition compound. These figures show, on a larger scale than in the preceding figures, the end of the detonator fuze 15, carrying the ignition device proper. At the end of the detonating fuze is disposed the plug 34, carried by a tube 33, and which in turn carries inside a container 35 the powder explosive, or ignition compound 36. Inside said powder, explosive, or compound is disposed the filament 37, at which terminates the conductors 19 and 19^1. In hitherto existing devices of this kind the plug 34 is tight and the container 35 is of varnished cardboard. According to the invention, said container 35 is an hygroscopic substance such as unvarnished cardboard, and the plug 34 is itself made of a substance permeable to water. The device in question is placed at the bottom of the perforator, as in the preceding case. If intrusion of water takes place, as the plug 34 and the unvarnished cardboard allow it to filter through, said water will wet the powder or compound inside the chamber 35, thereby preventing any possibility of firing.

In the device illustrated in Fig. 12, the

plug 34 can be of an impermeable substance, but in such case there are provided, in the wall itself of the tube 33, holes 28 which are covered by a sheath of cellophane 39 up to the time when the apparatus is mounted in the body of the perforator, said cellophane sheath being removed at that moment. The operation of this device is the same as that of the preceding device.

In addition to the device intended to prevent firing in the case of intrusion of water into the apparatus, it will moreover be possible, according to the invention, to provide warning devices disposed at ground level and connected electrically to the apparatus in the borehole, as for example a neon lamp lighting up when intrusion of water takes place. Said warning device could, moreover, be used separately, but it is in all cases preferable to duplicate it with an automatically operating device for preventing firing such as the one which has just been described.

In the embodiment illustrated in Figs. 13 and 14, which constitute a variant of the device illustrated in Fig. 1, the perforating apparatus comprises a pressure-resisting hollow cylindrical jacket 50, closed at its top and bottom by caps 51 and 52 held tight, and comprising a certain number of apertures 53, provided in its side wall. The apertures 53 are, preferably, distributed longitudinally over the length of the jacket 50 and staggered angularly along the longitudinal axis of the latter, and they are closed by suitable plugs 54, for example threaded plugs of normal type, washers 55 being interposed in order to ensure tightness. The jacket 50 can be fixed to a supporting cable 67 (not shown), by means of which it can be moved inside the bore.

In the jacket 50 are mounted a certain number of members with hollow charges 56, each comprising, as before, a jacket 4, an explosive charge 5, and a conical liner 6. The internal wall of the jacket 4, which surrounds the conical liner 6, converges towards the rear and the angle of the cone 6 is greater than the angle of the chamber receiving the charge in the jacket 4, said angles being for example respectively 55° and 30°.

Each jacket 4 comprises a cylindrical forward part 60, extending beyond the charge 5 and the packing 6, with a forward part intended to lodge in one of the apertures 53. Each jacket 4 likewise comprises a rear part 61 which can be lodged in a recess 62 provided in the internal wall of the jacket 50, on the side opposite to the orifice 53. The rear part 61 and the recess 62 can be slightly conical, as can be seen in Figs. 1 and 2, in order to facilitate assembly. Each jacket 4 is held in position by a plug 54 lodged in the corresponding orifice 53. As in the device illustrated in Fig. 1—2, each jacket 4 comprises a slot open towards the rear, communicating with a tubular duct inside which the fuze is inserted. Said fuze 15, when it is in position, is separated from the explosive charge 5 by a relatively thin partition 56; the firing of the fuze 15 can be effected in any suitable manner from ground level. For example, said firing can be effected by a primer 68, itself fired electrically by a source of electrical energy 69 provided at ground level. A surface terminal 69 can be earthed at 70, and the other terminal can be connected in series with a switch 71 and a conductor 72 disposed in the cable 67 and going to the primer 68, the circuit being completed through the ground.

In order to assemble the perforator, the cap 51 is removed and the primer 68 and the fuze 15 inserted in the jacket 50. The plugs 54 being removed, the jackets 4 are introduced into the orifices 53 and driven in until they are suitably supported by the recesses 62 and the orifices 53. During this operation the detonating fuze passes through the slots provided through the rear extremities of the jackets 4, in order to penetrate into the tubular ducts 64. The orifices 53 are then closed by the plugs 54 after insertion of the washers 55 which ensure tightness.

The order of the operations can also be reversed and the primer fixed last.

In operation, the assembly is brought to the desired level inside the bore-hole (not shown) by means of the cable 67 and the switch 71 is closed. This has the effect of operating the primer 68 and causing the charges 5 to explode almost simultaneously.

As the members are kept in perfect alignment with the orifices 53, an efficient blast of gases is obtained, without the jacket 50 being damaged by said blasts of gases. Furthermore the transverse forces developed around said charges by the detonation of the latter, are substantially reduced, due to the inertia of the jacket of said charges, so that no appreciabel deformation of the jacket 50 is produced.

For the formation of the gas blast, it is important that the symmetry of the charge, of its conical liner and of the opening receiving the charge inside the cartridge, be accurately maintained. It has been found that even the threads provided inside the cartridge can adversely change the symmetry of the assembly and

impair the formation of the blast. The apparatus will therefore be designed in such manner than on placing the charge in position, the least possible asymmetry is produced around the latter.

Figure 15 illustrates more particularly a variant of the embodiment of the hollow charges themselves, adapted to be utilised in a bore-hole perforator as described hereinbefore. In Fig. 15, 4 designates, as before, the external jacket of the hollow charge constituted in *per se* known manner.

5 designates the explosive charge proper, comprising at its forward part a conical recess limited by a liner 6, of metal or any material, capable of functioning as a liner in the hollow charges.

At the rear of the charge 5 is disposed the priming charge 74, itself intended to be ignited, for example by a Bickford fuze 15.

According to the invention, said charge 74 is separated from the charge 5 by a chamber 76, limited on the side facing the charge 74 by a very blunt cone (of which the angle at the vertex is of the order of 120°), and which is empty or filled with inert material.

A liner 77, of metal or of any suitable material, constitutes if need be the separation between the charge 74 and the chamber 76; with pre-compressed charges this space is no longer essential.

A further wall 78 of any suitable substance, can separate the chamber 76 from the charge 5, but said wall is not at all essential to proper working.

The depth of the chamber 76, that is to say the distance which separates the charge 74 from the charge 5, must be relatively small so that the shock wave set up by the explosion of the charge 74 effects ignition of the charge 5 over the whole of its base, and in a regular manner. In other words, the priming charge must be provided with a short firing adjustment in such manner that the shock wave is not concentrated at the moment of reaching the charge and does not perforate it.

The surface 77, instead of being of conical form as indicated above, may be cup-shaped or any other suitable form.

In all cases it is necessary, according to the invention, for the thickness of the additional chamber 76 to be so dimensioned in relation to its width that the shock wave of the charge 74 effects solely the ignition of the charge 5, without penetrating into said charge by the formation of a perforating blast.

What we claim is:—

1. A device containing hollow explosive charges for perforating or cutting casings lining the walls of bore-holes, comprising a plurality of explosive charges mounted in an elongated cylindrical steel body, the positioning of said charges being effected by lateral introduction into said cylindrical body.

2. Device as claimed in claim 1, characterised in that the cylindrical body is hollow throughout its height.

3. Device as claimed in claim 1, characterised in that the cylindrical body comprises separate cavities or chambers inside which the charges are introduced, said cavities providing laterally in relation to the hollow charges, spaces filled with air or with compressible materials.

4. Device as claimed in claim 3, characterised in that each of the chambers is closed by a cap adapted to withstand the external hydrostatic pressure and which is pierced by the explosion blast of the charge.

5. Device according to claim 1, characterised in that centering devices are provided for centering each charge in the body of the apparatus.

6. Device according to claim 1, characterised in that each charge has a jacket manufactured of a plastic and resilient substance such as elastic rubber.

7. Device as claimed in claim 1, characterised in that a conical liner, disposed in the forward cavity of each charge, is manufactured of a substance volatilizable at a temperature below 600° C., for example a metal such as zinc.

8. Device as claimed in Claim 1, characterized in that the ignition of each charge is effected by means of a detonating fuze, introduced into a slot provided at the rear of each charge.

9. Device as claimed in Claim 1, characterised in that, in order to prevent the intrusion of water or of mud which may take place to the interior of the apparatus from having the effect, by suppressing the air-filled cavities, of causing, at the time of the explosion of the charges, the explosion of the apparatus and of the casing, safety devices are provided which prevent the firing of the hollow charges if said intrusion has taken place.

10. Device as claimed in Claims 1 and 9, characterized in that said safety devices, in the case of electrical ignition, prevent the passage of the current to the ignition filament.

11. Device as claimed in Claims 1 and 9, characterised in that said safety devices allow the ignition powder to become wet.

12. Device as claimed in Claim 1, characterised in that, behind each hollow

charge proper intended to effect perforation, firing charges are provided separated from the former by chambers of relatively small dimensions, which are empty or filled with porous inert materials.

13. The device containing hollow explosive charges constructed, arranged and adapted to operate substantially as hereindescribed and with reference to Figs. 1 to 4 or 5 of the accompanying drawings.

14. The device containing hollow explosive charges constructed, arranged and adapted to operate substantially as hereindescribed and with reference to any of Figs. 6 to 12 of the accompanying drawings.

15. The device containing hollow explosive charges constructed, arranged and adapted to operate substantially as hereindescribed and with reference to Figs. 13 and 14 of the accompanying drawings.

16. The hollow explosive charge when used for a perforator as claimed in any of the preceding claims, constructed, arranged and adapted to operate, substantially as herein described with reference to Fig. 15 of the accompanying drawings.

Dated this 23rd day of January, 1950.

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Agent for Applicants.

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Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

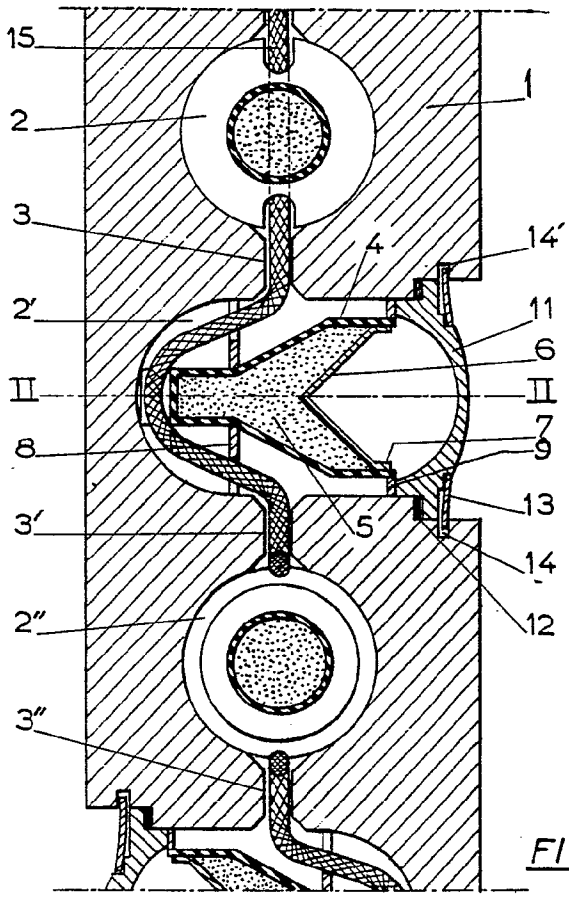

FIG. 1

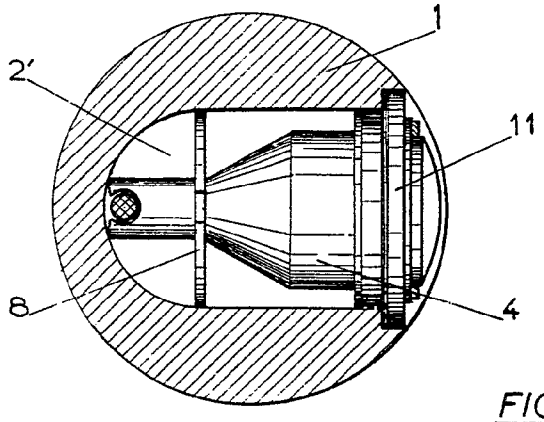

FIG. 2

677,824 COMPLETE SPECIFICATION

6 SHEETS This drawing is a reproduction of the Original on a reduced scale.

SHEETS 1 & 2

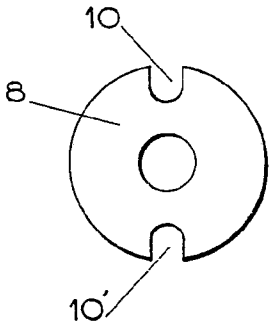

FIG. 3

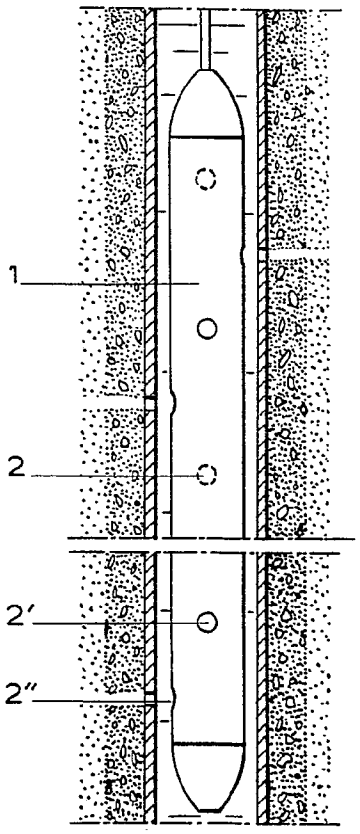

FIG. 4

G.1

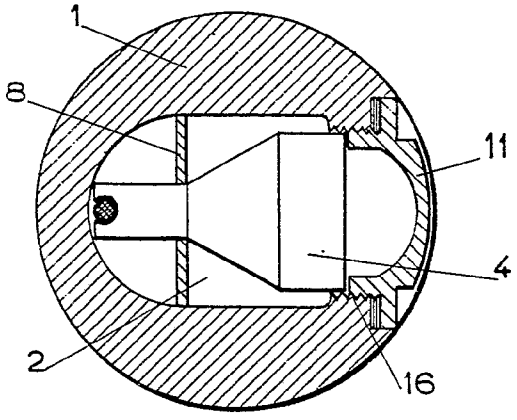

FIG. 5

3. 2

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677,824 COMPLETE SPECIFICATION
6 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

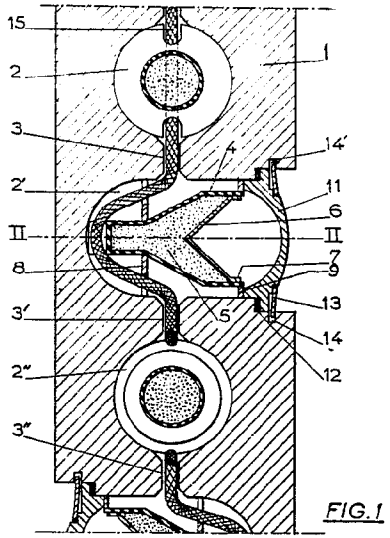

FIG. 1

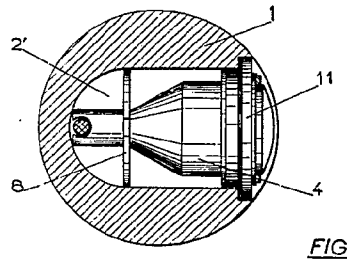

FIG. 2

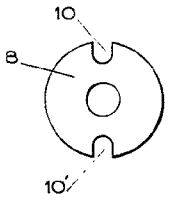

FIG. 3

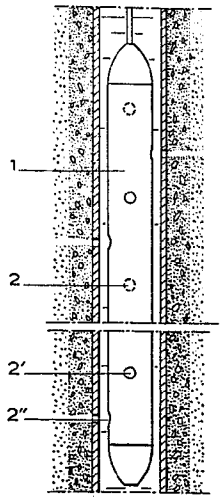

FIG. 4

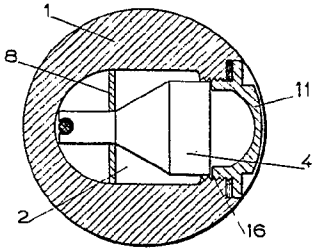

FIG. 5

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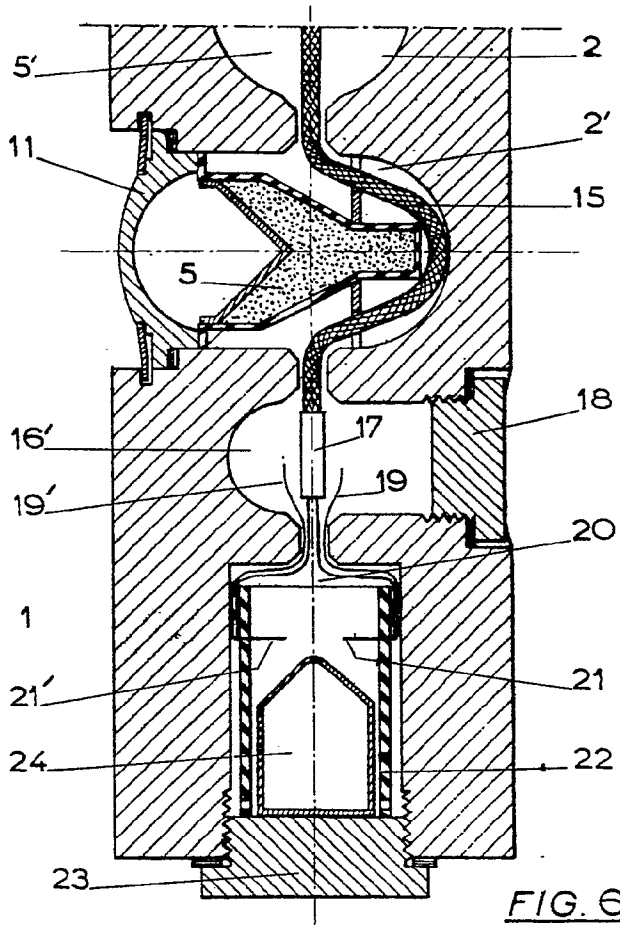
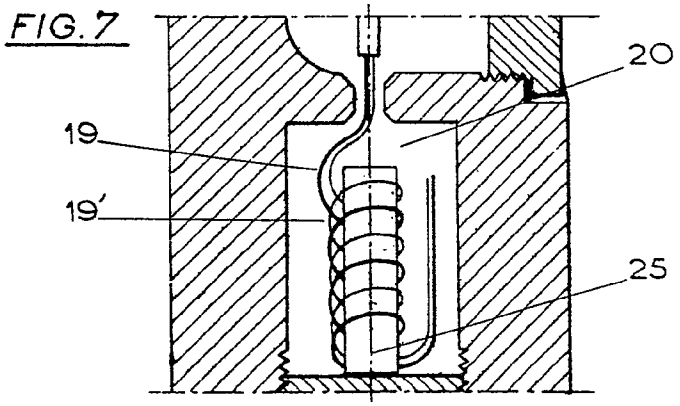


FIG. 6

FIG. 7



677,824 COMPLETE SPECIFICATION

6 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*

SHEETS 3 & 4

FIG. 8

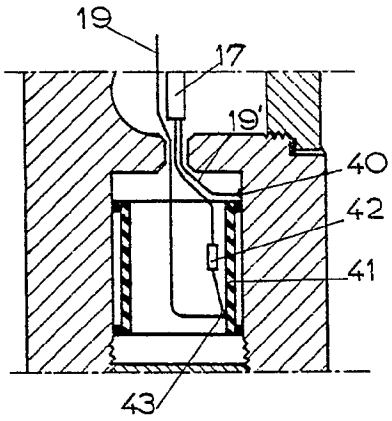


FIG. 9

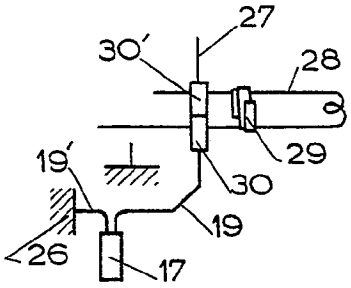
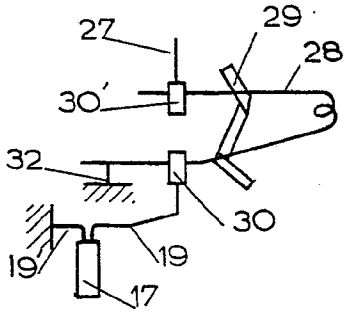


FIG. 10



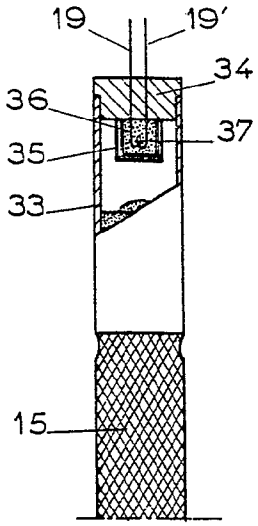


FIG.11

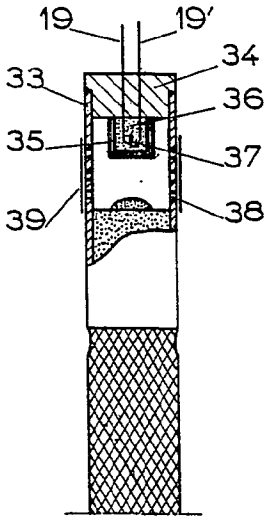


FIG.12

677,824 COMPLETE SPECIFICATION
6 SHEETS This drawing is a reproduction o
the Original on a reduced scale
SHEETS 3 & 4

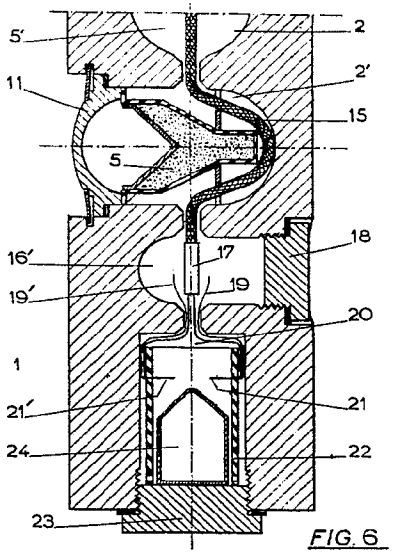


FIG. 6

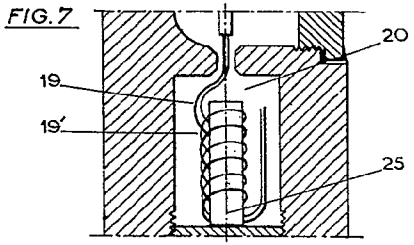


FIG. 7

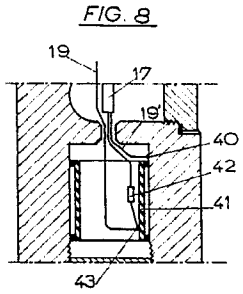


FIG. 8

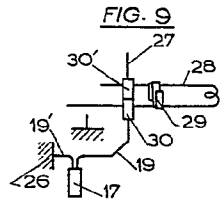


FIG. 9

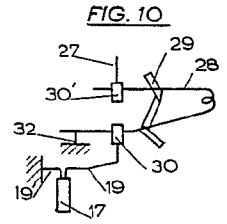


FIG. 10

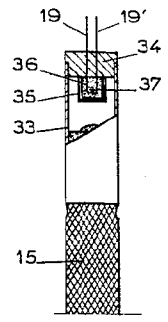


FIG. 11

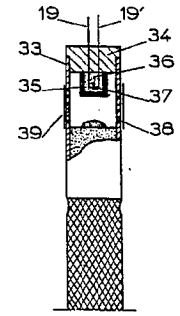


FIG. 12

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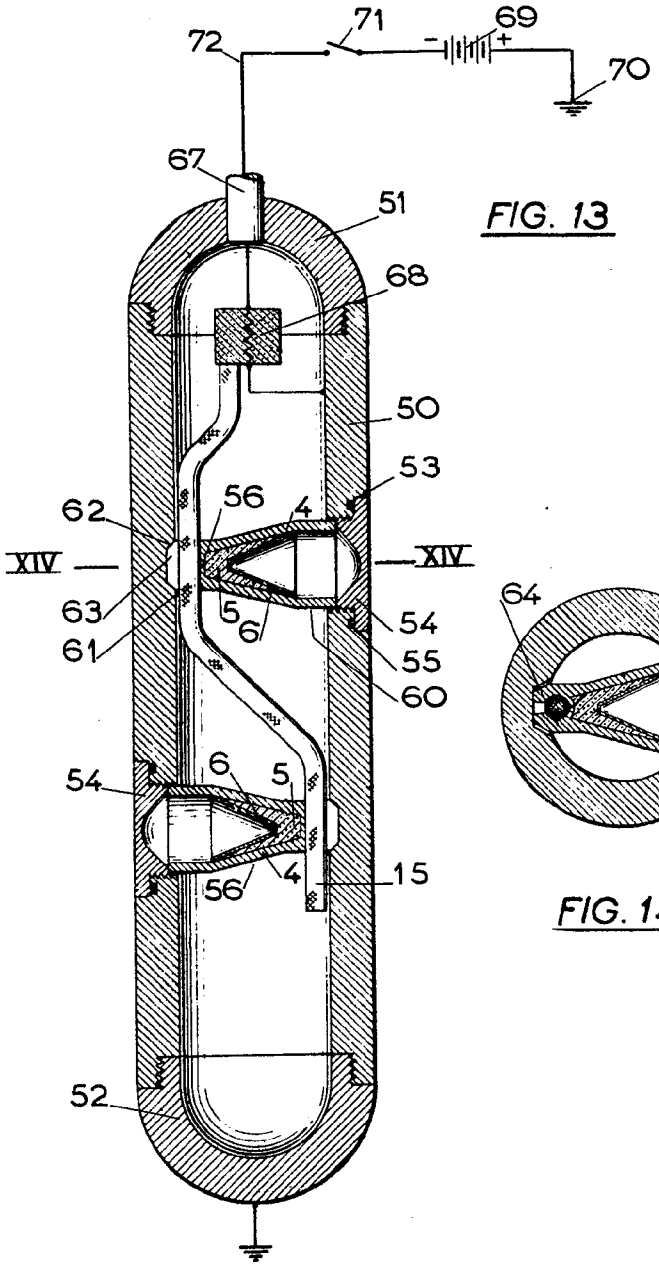
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FIG. 13

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FIG. 14

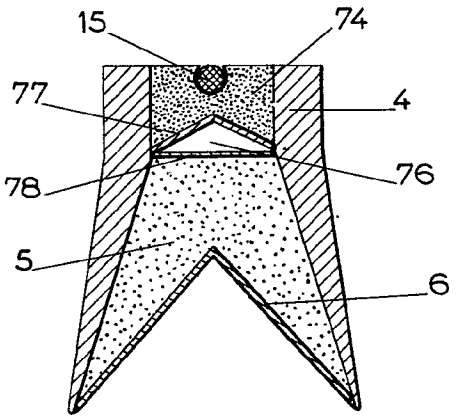

FIG. 15

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